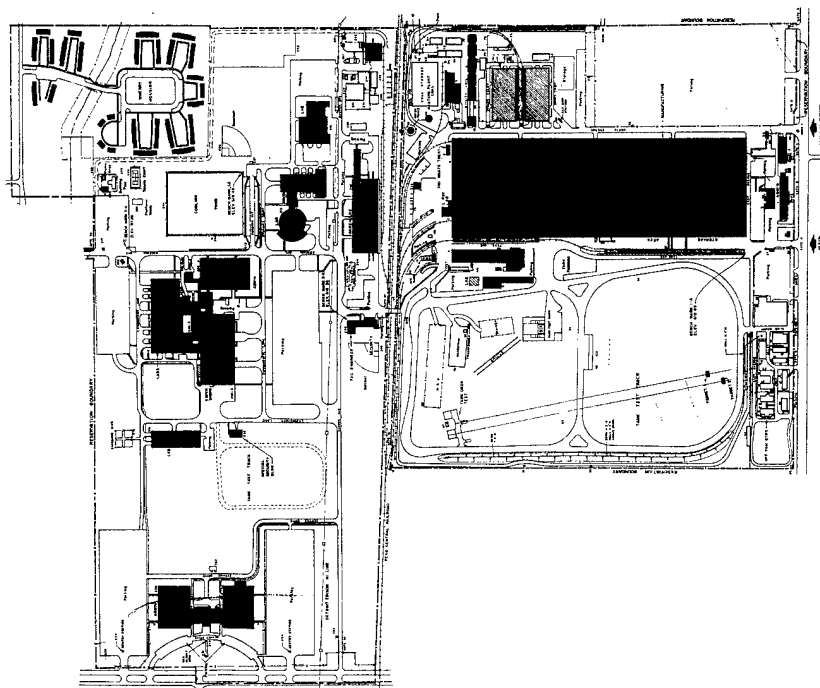


ENERGY ENGINEERING ANALYSIS PROGRAM

FINAL REPORT — INCREMENTS A, B, D, F AND G

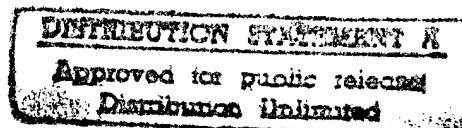
VOLUME 1 — EXECUTIVE SUMMARY

U. S. ARMY
DETROIT ARSENAL, MICHIGAN



PREPARED FOR:
U. S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT

DTC QUALITY INSPECTION 2



PROJECT A1-30-20
CONTRACT NO. DACA45-80-C-0091

SEPTEMBER 1983

PREPARED BY:

GARD, INC.

A SUBSIDIARY OF GATX
7449 NORTH NATCHEZ AVENUE
NILES, IL 60648
(312) 647-9000

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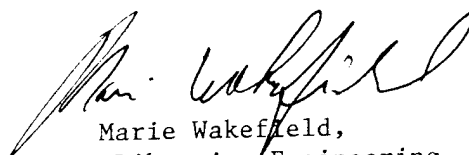


DEPARTMENT OF THE ARMY
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A1-30-20
FINAL REPORT
VOLUME 1 - EXECUTIVE SUMMARY

ENERGY ENGINEERING ANALYSIS PROGRAM
INCREMENTS A, B, D, F AND G
DETROIT ARSENAL
AND
SATELLITES

CONTRACT NO. DACA45-80-C-0091

Prepared by
GARD, INC.
Niles, Illinois 60648

For
Department of the Army
Corps of Engineers
Omaha District

September, 1983

PREFACE

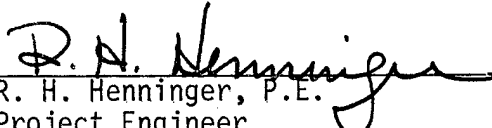
This Final Report summarizes all work accomplished under Increments A, B, D, F and G of the Energy Engineering Analysis Program conducted at the Detroit Arsenal (DA) in Warren, Michigan and Satellite Operations at Arsenal Acres, Pontiac Storage Facility and Keweenaw Field Station. The tasks assigned under these Increments have been completed and are documented within.

The study objective was to develop a systematic plan of projects that would result in the reduction of energy consumption in compliance with the Army Facilities Energy Plan (AFEP) and to prepare Project Development Brochures (PDB's), DD Forms 1391 and supporting documentation for those projects deemed feasible. The projects developed as a result of this study are described in this report. Project Development Brochures and DD Forms 1391 have been prepared in accordance with Army procedures and are bound separately.

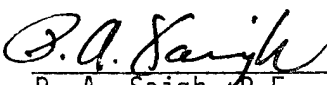
GARD has sincerely appreciated the cooperation that has been extended by members of the Omaha District, Corps of Engineers especially the Program Managers, Mr. S. Owens and Mr. E. Liu, and the Facilities Engineering staff of DA headed previously by Mr. R. Lang and currently by Mr. W. Chaudoin.

The GARD project team that conducted this study included K. Spaulding, M. Hormann, C. Schafer, N. Leslie, R. Hedrick and M. Hagen.

Respectfully submitted,


R. H. Henninger, P.E.
Project Engineer

Approved by:


P. A. Saigh, P.E.
Director, Government Programs

ADDENDUM TO FINAL REPORT

The reader's attention is directed to the following which has taken place since submittal of the Advanced Final Reports for Increments A, B, D, F and G.

1. In response to Revised ECIP Guidance issued 12/31/82, the Omaha District, Corps of Engineers has reviewed and revised all of the ECIP calculations for each of the five qualifying projects for which PDBs and DD 1391s have been prepared. Appropriate changes have been made in pertinent sections of the Project Development Brochures and DD Forms 1391 only. All of the ECOs that are part of ECIP Projects No. A-1, A-2, B-1, B-2 and D-1, still qualify when evaluated under the new ECIP guidelines. The Main Report as well as the Executive Summary have not been revised to include the new SIR calculations.
2. Recently, Modification 4 has been authorized. This new work will address Increments A, B, F and G for five additional buildings at DA, i.e., Buildings 229, 231, 249, 250 and 252. The results of this work will be covered by a separate Final Report.

EXECUTIVE SUMMARY
ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)
INCREMENTS A, B, D, F AND G
DETROIT ARSENAL AND SATELLITES

Authorization for Study

This Energy Engineering Analysis Program (EEAP) for Detroit Arsenal and supported satellites at Arsenal Acres, Pontiac Storage Facility and Keweenaw Field Station was conducted under Contract No. DACA45-80-C-0091 issued by the Omaha District, Corps of Engineers to GARD, INC., Niles, Illinois on the 13 August 1980. The Scope of Work was structured into work increments with Increments A and B authorized under the original contract, Increment G authorized under Modification 1 dated 3 March 1981 and Increments B (expanded EMCS), D and F authorized under Modification 2 dated 20 May 1982.

Objectives and Scope

As stated in the EEAP Scope of Work the overall objectives were:

- a) "Develop a systematic plan of projects that will result in the reduction of installation energy consumption in compliance with the Army Facilities Energy Plan."
- b) "Develop Coordinated Basewide Energy System Plans."
- c) "Prepare Project Development Brochures (PDBs), DD Forms 1391 and supporting documentation for all feasible energy conservation projects."

The Scope of Work further defined the objectives and scope of each work increment to be as follows:

Increment A - ECIP* Projects for Buildings and Processes

*ECIP - Energy Conservation Investment Program

- Increment B - ECIP Projects for Utilities, Energy Distribution Systems and Energy Monitoring and Control Systems (EMCS)
- Increment C - Renewable Energy Systems Projects
- Increment D - Cogeneration and Solid Waste Plants Projects
- Increment E - Central Boiler Plant Projects
- Increment F - Facilities Engineer Conservation Measures
- Increment G - Projects Identified in Increments A and B that do not qualify under ECIP criteria

This submittal presents the final results for Increments A, B, D, F and G through a description of those energy conservation opportunities (ECOs) and ECIP projects that were identified and evaluated as part of these work increments. Increments C and E have not been authorized at this time for Detroit Arsenal.

Approach

Numerous retrofit modifications referred to as energy conservation opportunities (ECOs) were identified for each building, system, and central plant studied. Each ECO was evaluated separately using the life cycle costing method described in the ECIP guidance included as Annex F of the AFEP. Energy savings were determined for each ECO and life cycle benefits were calculated using current mid FY82 fuel costs, which were escalated over the expected life of the modification. Implementation or construction costs were also determined using current FY82 cost data which were escalated to the midpoint of construction assuming an FY86 project award date. Comparison of ECOs was done on the basis of energy-to-cost (E/C), benefit-to-cost (B/C), and

simple amortization period (SAP) ratios in accordance with ECIP criteria. Qualifying ECOs were grouped into ECIP projects under the guidance of the Facilities Engineering Staff. Then, once adjustments were made for any interactive or synergistic ECO effects which were present within an ECIP project, the PDB and DD Form 1391 were prepared for each ECIP project. Non-qualifying ECOs became candidates for implementation as an Increment F or G project.

Facility Description

Detroit Arsenal (DA) is situated in Warren, Michigan just north of Detroit and is headquarters for the U.S. Army Tank-Automotive Command (TACOM). TACOM is responsible for the acquisition and readiness of combat and tactical vehicles. To this end, it supports government owned and contractor operated (GOCO) manufacturing plants at DA and Lima, Ohio, an extensive storage facility for DoD industrial mobilization equipment near Pontiac, Michigan, R&D laboratories at DA and a GOCO research and vehicle testing center at Keweenaw Field Station near Houghton, Michigan. In addition, officer's quarters and military housing are provided on the DA site and at Arsenal Acres, an off-post housing area located two miles south of DA.

The Detroit Arsenal installation is composed of 105 buildings on 341 acres of land. The size of the buildings range from a 24 square foot guard-house to a 1,114,000 square foot tank production facility. The east site (Figure 1) contains the tank production and field testing facilities along with quarters buildings, food services, maintenance shops and central heating plant. The west site (Figure 2) houses administration buildings, R&D laboratories, and storage buildings. A total of 41 buildings (Table 1) at DA were identified for study under this contract representing some 2,437,240 gross square feet and constituting the majority of buildings actively occupied

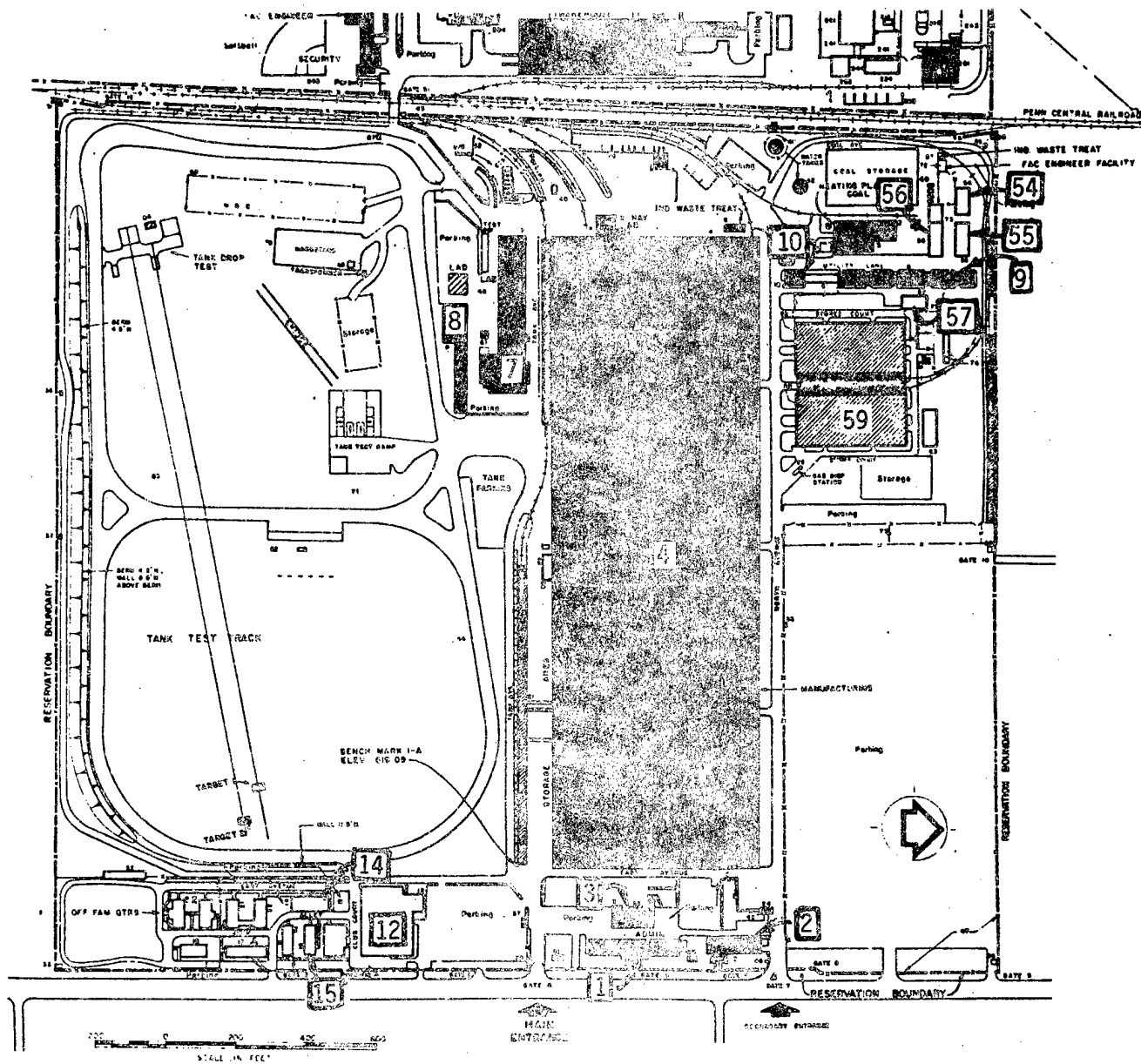


Figure 1 EAST SITE PLAN

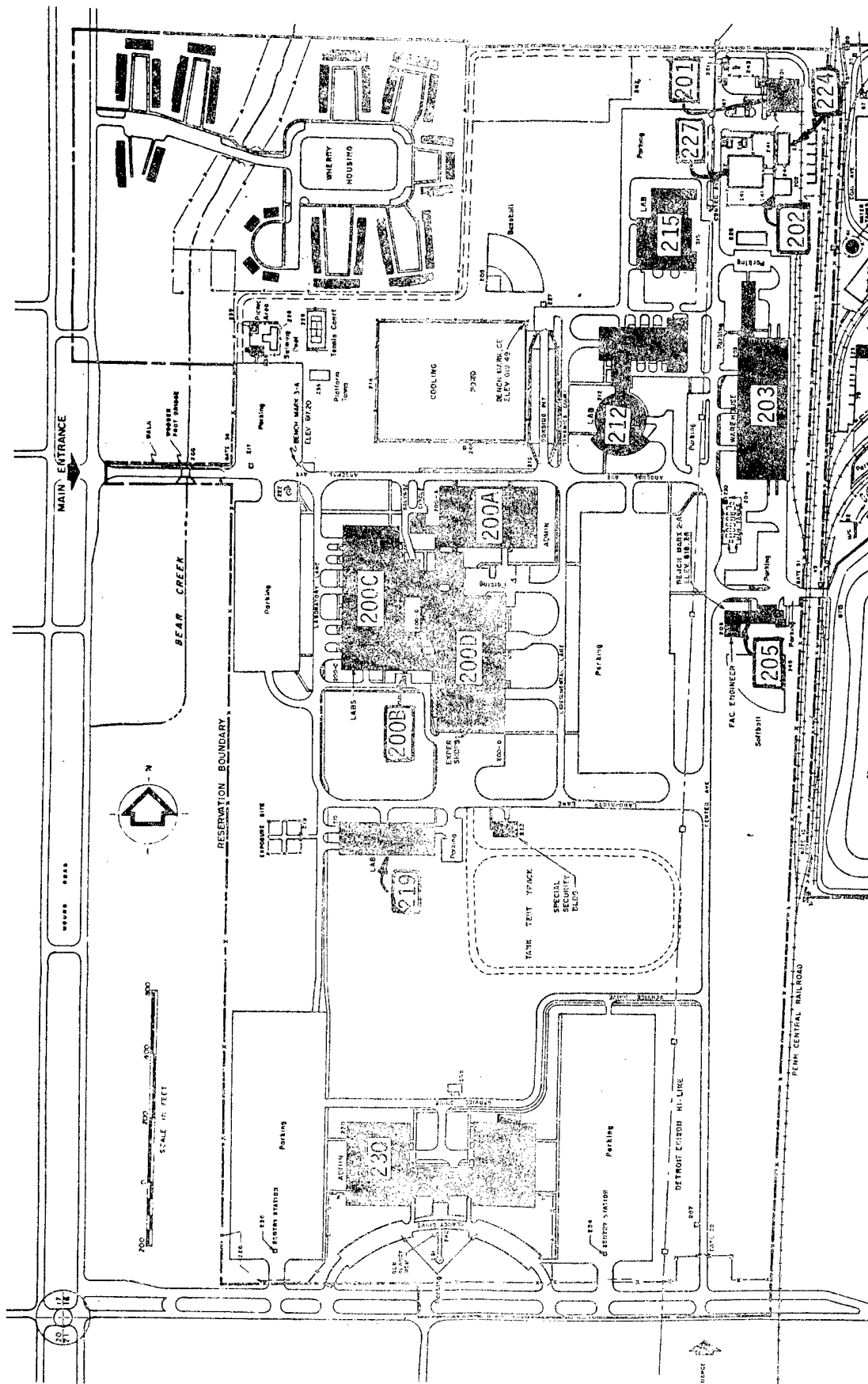


TABLE 1
BUILDINGS DESIGNATED FOR STUDY AT
DETROIT ARSENAL

Building Number	Title	Function	No. Floors	Gross Sq. Ft.
1	Administration	Administration/ General Purpose	4	53,532
2	Dispensary	Institutional	1	7,540
3	Telephone Exchange	Utility	1	6,205
4	Combat Vehicle Plant	Industrial	1	1,114,381
5	Central Heating Plant	Utility	2	29,600
7	Vehicle and Machine Repair	Industrial	3	63,932
8	Experimental Laboratory	Administration/ Research	1	13,100
9	Maintenance Shop	Service	1	15,742
10	FE Maintenance Shop	Service	1	2,267
12	Applied Instruction	Administration/ Training	1	30,730
13	Open Mess (Officer's Club)	Institutional	1	5,369
14	Open Mess (NCO)	Institutional	1	4,172
15	Bachelor's Enlisted Quarters	Housing	2	4,478
17	Family Housing	Housing	1	2,879
18	Post Exchange (PX)	Institutional	2	4,500
40	Track/Suspension Laboratory	Administration/ Research	1	1,642
54	FE Maintenance Shop	Service	1	3,475
55	FE Maintenance Shop	Service	1	3,920
56	FE Maintenance Shop	Service	1	6,279
57	Wash Rack/Storage	Service	1	3,120
58	General Storehouse	Storage	1	49,960
59	Lift Truck Repair	Service	1	50,037
61	FE Maintenance Shop	Service	1	2,914

TABLE 1 (Con't.)
BUILDINGS DESIGNATED FOR STUDY AT
DETROIT ARSENAL

Building Number	Title	Function	No. Floors	Gross Sq. Ft.
200A	Research & Development Activities	Administration/ General Purpose	2	126,433
200B	Lecture Hall	Administration/ General Purpose	2	49,544
200C	R & D Testing Laboratories	Administration/ Research	1	82,265
200D	Experimental Shops	Administration/ Research	1	112,461
201	Printing Plant	Administration/ Communications	1	10,466
202	Roads and Grounds	Service	1	2,450
203	General Purpose Warehouse	Storage	1	83,967
205	FE Administration/ Fire/Security	Administration/ Special	1	9,491
212	Propulsion Systems Laboratory	Administration/ Research	3	119,479
215	Vehicle/Track and Suspension Laboratory	Administration/ Research	1	45,268
219	Model Shop	Administration/ Research	1	30,400
224	FE Maintenance Shop	Service	1	3,920
225	General Storehouse	Storage	1	3,920
227	Salvage and Surplus Storage	Storage	1	12,000
228	Swimming Pool	Institutional	1	-
230	TARCOM/TARADCOM Headquarters	Administration/ General Purpose	2	264,474
232	Cooling Tower	Utility	1	-
238	Bath House	Institutional	1	968
TOTAL				----- 2,437,280

and presenting opportunities for saving energy.

The Arsenal Acres site covers 6.6 acres and has 7 family housing units, all of which were identified for study under this contract. Table 2 summarizes the general characteristics of each residence.

The Pontiac Storage Facility (PSF) includes 5 buildings totalling 607,633 square feet on a 31 acre site. Two buildings at PSF have been identified for study. These are listed in Table 3.

The Keweenaw Field Station (KFS) is an arrangement of 7 buildings located on a 27.3 acre tract of Houghton County Airport land in Michigan's upper peninsula leased by the Government. All KFS buildings were identified for study. Table 4 presents a summary of each building.

The current population for DA totals about 6,300 people. This level is not expected to vary significantly over the next five years. Population levels at the satellites have been steady at 6 to 7 families at Arsenal Acres, 5 people at PSF, and 15 people at KFS.

Energy Distribution Systems and Central Plants

The Detroit Arsenal utilizes three major forms of energy to support facilities operations: electricity, coal, and natural gas. Electricity is used for lighting, heating, cooling, ventilation, manufacturing, security, etc. systems. Coal and natural gas are utilized by the central heating plant to generate steam for heating, manufacturing and prime mover systems. Natural gas is also used as a source for heating and manufacturing systems. Table 5 summarizes the energy distribution systems that are in use at DA along with the central plants that supply these systems.

Electricity and natural gas are the only utilities distributed to Arsenal Acres. PSF utilizes fuel oil for heating as well as electricity. At KFS

TABLE 2
BUILDINGS DESIGNATED FOR STUDY AT
ARSENAL ACRES

Building Number	Title	Function	No. Floors	Gross Sq. Ft.
301	Commanding Officer's Quarters	Housing	2	3,544
302	Senior Officer's Quarters	Housing	2	3,248
303	Senior Officer's Quarters	Housing	2	3,248
304	Junior Officer's Quarters	Housing	2	2,672
305	Junior Officer's Quarters	Housing	2	2,672
306	Junior Officer's Quarters	Housing	2	2,672
307	Junior Officer's Quarters	Housing	2	2,672
TOTAL				----- 20,728

TABLE 3
BUILDINGS DESIGNATED FOR STUDY AT
PONTIAC STORAGE FACILITY

Building Number	Title	Function	No. Floors	Gross Sq. Ft.
1	General Warehouse	Storage	1	607,173
7	Heating Plant and Water Tower	Utility	1	363
TOTAL				----- 607,536

TABLE 4
BUILDINGS DESIGNATED FOR STUDY AT
KEWEENAW FIELD STATION

Building Number	Title	Function	No. Floors	Gross Sq. Ft.
1	Research Facilities	Administration/ General Purpose	1	8,971
2	Vehicle Garage and Machine Shop	Service	1	4,000
3	Vehicle Storage	Storage	1	5,600
4	Vehicle Storage	Storage	1	4,000
5	Research & Testing Laboratory	Administration/ Research	1	4,000
6	Parts Storage	Storage	1	1,000
7	Parts Storage	Storage	1	1,000
TOTAL				----- 28,571

TABLE 5
DETROIT ARSENAL
DISTRIBUTION SYSTEMS AND CENTRAL PLANTS

Energy Form	Source	Distribution System	End User
Electricity	Detroit Edison Co.	Primary Feeder @ 40 KV	Substation A, Building 5
		Secondary Feeders @ 4.8 KV	Specific Loads (Buildings, Perimeter Lighting, Tenants)
Electricity	Detroit Edison Co.	Primary Feeder @ 4.8 KV	Substation B, Building 12
		Secondary Feeders @ 240/120 V	Cantonment Area and Building 25
Steam	Central Heating Plant Building 5 Capacity: 300,000 LB/HR Steam	Below Grade Pipes in Tunnels, Buried Pipes and Above Ground Pipes @ 175 psi	All buildings except sentry stations and Building 238
Condensate	All buildings supplied with steam by Building 5	Below Grade Pipes in Tunnels and Buried Pipes	Building 5
Natural Gas	Consumers Power Co.	From Building 5 via Underground Pipes	East Site Buildings
Natural Gas	Consumers Power Co.	Underground Pipes	Buildings 200B, 200C, 200D, and 238
Compressed Air	Compressor Plant - Building 5	Below Grade Pipes in Tunnels and Buried Pipes 100 psi	Manufacturing and Administration Buildings

electricity, natural gas, and fuel oil are used to support facility operations. Table 6 summarizes characteristics of each energy distribution system for the satellites.

Energy Conservation Actions Since FY75

DA recognized early the need for responsible energy management. When conservation goals were established in Executive Order No. 12003, DA responded by initiating several projects and programs.

The following list are examples of some of the energy conservation changes which have been made at DA, Arsenal Acres, and KFS.

Detroit Arsenal

- All thermostats for heating, air conditioning, and hot water systems were reset in accordance with Army standards.
- High efficiency lighting was installed in 2 manufacturing and service buildings.
- Thermostats and control valves were installed on steam radiators which were without existing individual controls.
- Two-step thermostats and valves were installed on unit heaters with only on/off controls in high bay areas.
- Outdoor weatherstats and valves were installed in the steam mains of 3 buildings to eliminate heating when outdoor temperature is above 45°F.
- Lighting levels were reduced to OSHA minimum where possible, e.g., stairwells, open office areas, and corridors.
- Overhead doors were replaced or removed and openings bricked up to reduce infiltration of 10 buildings.
- Roof insulation was installed on 5 buildings.

TABLE 6
ENERGY DISTRIBUTION SYSTEMS FOR SATELLITES

	Energy Form	Source	Distribution System	End User
Arsenal Acres	Electricity	Detroit Edison Co.	Primary Feeder @ 15.2 KVA Secondary Feeder @ 230/115 V	Buildings 301, 302, 303
	Electricity	Detroit Edison Co.	Primary Feeder @ 15.2 KVA Secondary Feeder @ 230/115 V	Buildings 304, 305, 306, 307, Guardhouse, Streetlights
	Natural Gas	Consumers Power Co.	From Utility Bldg. via Underground Pipes	All Buildings
Pontiac Storage Facility	Electricity	Detroit Edison Co.	Primary Feeder @ 4800 V Aerial Line	Buildings 1, 2 and 7
	Fuel Oil	Underground Storage Tanks	Buried Pipes	Buildings 1 and 7
	Hot Water	Building 7 (BL-1) Capacity: 2512 LBS/HR Fuel: Fuel Oil	Buried Pipes	Building 6
Keweenaw Field Station	Propane			Vehicles
	Electricity	Ontonago County Rural Electrification Association	Aerial Lines	Buildings 1, 2, 3, 5, 6 & 7
	Natural Gas	Michigan Power Co.	Buried Pipes	Buildings 1, 2 & 5

- Fiberglas insulation was installed on the walls of several metal buildings used for FE shops and storage.
- The window glazing and sash of 2 buildings were replaced with new insulating sash and thermopane windows.
- Sections of the steam supply and condensate return systems were replaced and/or insulated.
- Exterior walls were replaced with insulating panels in Buildings 200A and 215.
- The exterior windows of Building 4 were replaced with insulating panels.
- An EMCS system was installed to monitor, timeclock, and reset control points for the heating and cooling systems in 6 buildings.
- Load shedding controls were installed in 6 buildings.

Arsenal Acres

- Insulation was installed in attic of each residence.

Keweenaw Field Station

- Insulation was installed on the exterior walls and roof of all buildings.

Energy Conservation Studies

Since FY75, DA has contracted for one study that related to energy conservation: "Load Analysis for Building No. 4", AMC Project 4764565, 21 May 1976. As a result of this study the entire electrical distribution system of the Tank Plant (Building 4) was rehabilitated under Contract DACA45-77-C-0132, dated May 1977.

Historical Energy Data

Total annual facility-related energy consumption for DA and associated

satellites in terms of source energy for the years FY77 through FY80 is shown in Figure 3. Each form of energy has been converted to its heat energy equivalent to reflect source energy requirements. Comparison on an annual historical basis to FY75 consumption is shown in Table 7.

The historical energy consumption can also be expressed in terms of energy use per gross square foot floor area. This factor, i.e., energy use index (EUI), is a measurement of an installation's performance and can be used to compare energy usage of similar installations. Table 8 and Figure 4 summarizes the EUI for DA for FY75 through FY80. The trend indicates an increase in EUI for FY75 and FY77. Since FY77 the EUI has remained fairly steady. The percent change in EUI compares favorably with a percent change in heating degree days which indicates that weather related energy efficiency remained fairly constant.

Actual costs for purchased electricity, natural gas and coal were available from Detroit Arsenal prepared reports. Results for FY79 and FY80 were compiled and are presented in Table 9. Costs for electricity and natural gas are actual total costs incurred each period, i.e., they include taxes, fuel adjustment, surcharges, demand charges, etc. Demand charges for electricity which typically amount to about 35-40% of the total monthly electric bill are billed at a rate of \$5.80 per KW demand during onpeak periods. Energy charges are 2.95¢ per KWH (on peak) and 2.25¢ per KWH (off peak).

The billed utility costs for Arsenal Acres for FY77 through FY79 are summarized in Table 10 along with the average unit costs for each form of energy and total annual operating costs on a per square foot basis.

A breakdown of utility costs for PSF was unavailable.

A 12 month period of utility data was obtained for KFS from Michigan Technological University which is responsible for Site operations. Total

Quarterly
Energy
Consumption
(10⁹ BTU)

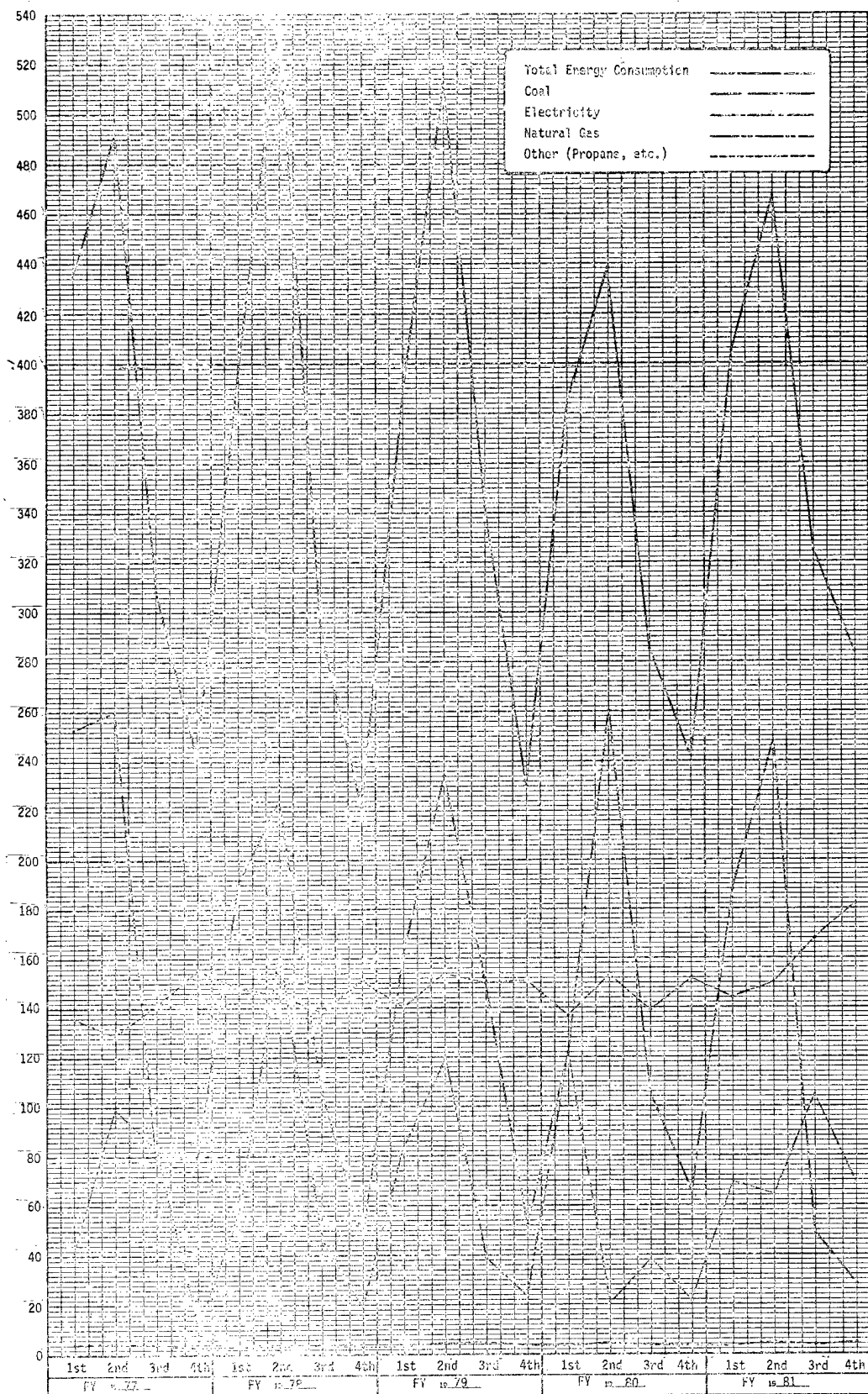


Figure 13 TOTAL ANNUAL ENERGY

TABLE 7
DETROIT ARSENAL
COMPARISON OF TOTAL ANNUAL
FACILITY - RELATED PURCHASED ENERGY CONSUMPTION

REPORTING PERIOD	ELECTRICITY		NATURAL GAS		COAL		OTHER		TOTAL	
	MBTU	CHANGE	MBTU	CHANGE	MBTU	CHANGE	MBTU	CHANGE	MBTU	CHANGE
75	425,006	-	234,792	-	572,138	-	12,312	-	1,305,255	-
76	524,990	+ 8.0%	291,081	+24.0%	588,820	+ 2.9%	13,608	+20.3%	1,419,589	+ 8.9%
77	560,304	+15.3%	229,312	- 2.3%	572,040	+17.5%	15,510	+26.0%	1,477,174	+13.2%
78	561,009	+19.5%	297,050	+22.3%	569,175	- 0.5%	13,276	+ 7.8%	1,450,510	+11.1%
79	534,663	+22.4%	265,589	+13.1%	595,675	+ 4.1%	16,386	+33.1%	1,472,313	+12.8%
80	581,462	+19.6%	202,148	-13.9%	552,710	- 3.4%	14,789	+20.1%	1,351,109	+ 3.5%

Notes

1. Source: DARCOM Energy Management Information System (DEIS) Reports
2. Includes consumption for Detroit Arsenal, Arsenal Acres and Keweenaw Field Station.
3. Results represent energy requirements at raw source energy point
4. FY75 used as base year. (-) change indicates saving, (+) change indicates increase

TABLE 8
DETROIT ARSENAL
HISTORICAL ENERGY CONSUMPTION
PER GROSS SQUARE FOOT

Assume Constant Real Property Inventory = 3,094,000 GSF
Includes Arsenal Acres, PSF and KSF

Period	Purchased Energy (MBTU)	Energy Use Index (KBTU/GSF)	% Change Compared to FY75
FY75	1,305,255	421,900	-
FY76	1,419,589	458,800	8.7
FY77	1,477,174	477,400	13.2
FY78	1,450,510	468,800	11.1
FY79	1,472,313	475,900	12.8
FY80	1,351,109	436,700	3.5

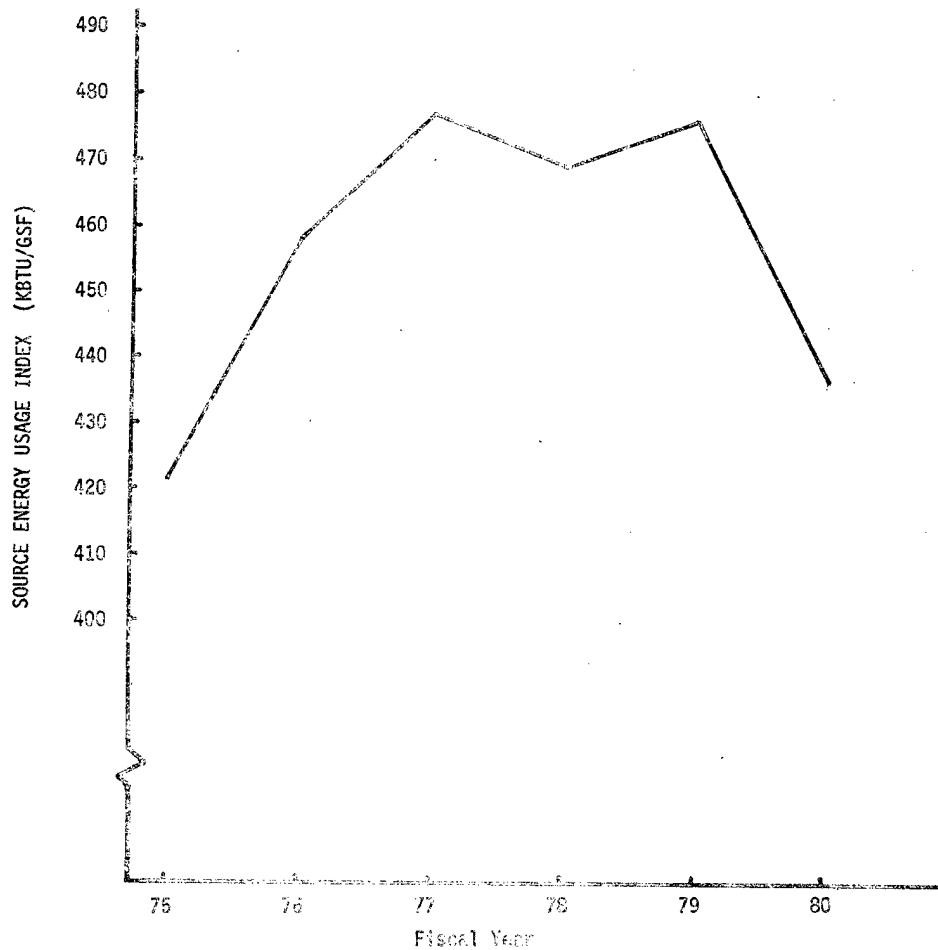


Figure 4 DETROIT ARSENAL AND SATELLITES
HISTORICAL SOURCE ENERGY USE INDEX

TABLE 9
DETROIT ARSENAL
SUMMARY OF OPERATING UTILITY COSTS
FOR FY79 - FY80

Period	Electricity (\$)	Natural Gas (\$)	Coal (\$)	Total	Estimated Operating Cost** (\$/SQ.FT.)
FY79	1,726,425	634,212	1,029,548	3,390,192	1.388
FY80	1,869,472	541,294	928,173	3,338,939	1.367

** Based upon 2,422,000 Sq.Ft. occupied

TABLE 10
 ARSENAL ACRES
 SUMMARY OF UNIT AND OPERATING
 UTILITY COSTS

Period	Electricity		Natural Gas		Total		Estimated Operating Cost \$/SQ.FT.
	TOTAL COST \$	UNIT COST \$/KWH	TOTAL COST \$	UNIT COST \$/CCF	TOTAL COST \$	UNIT COST \$/MBTU	
FY77	5,879	0.0427	7,159	0.2571	13,038	3.90	0.629
FY78	5,515	0.0446	6,116	0.2350	11,629	3.75	0.561
FY79	5,817	0.0475	7,195	0.2677	13,012	4.08	0.627

energy usage at KFS was 3,012 MBTU for the reported period of July 1980 thru June 1981. Assuming only Buildings 1, 2 and 5 are used extensively, KFS had an EUI of 177.5 KBTU/SQ.FT. The cost for natural gas averaged \$0.357 per CCF or \$3.46 per MBTU. Electricity costs averaged \$0.073 per KWH or \$21.48 per MBTU.

Building Energy Consumption Analysis

At DA, utilities are metered only as they enter the site. Submetering is more prevalent at the satellites. Where metered data was available, this was used to establish a building's annual energy usage rate. Establishing annual energy usage rates for all other buildings was done using various analytical methods. Estimated annual energy consumption for all types of energy are summarized in Tables 11 through 14 on a building-by-building basis for those buildings under study. Total energy consumption was calculated for each building by converting all units to BTU's and summing them for each energy type. An energy usage index was then obtained for each building by dividing the total energy consumption by the occupied floor area.

Summary of Recommended Projects

A brief description for each of the projects identified and evaluated under this Energy Engineering Analysis Program study is provided in Table 15. The funding requirements and energy and cost savings for each of these are summarized in Table 16. The projects presented in this table are listed in order of descending energy-to-cost ratios.

Implementation of all of the ECIP qualifying projects will require over \$4.7 million in funding and yield a total annual energy savings of 194,000 MBTU. This energy savings figure is based upon each project being independent of the others, and is exclusive of the effects of interactions between

TABLE 11
SUMMARY OF ESTIMATED ANNUAL BUILDING HEATING ENERGY CONSUMPTION
DETROIT ARSENAL, WARREN, MICHIGAN

BUILDING NUMBER AND TITLE	LOAD TYPE	ENERGY SOURCE	DESIGN LOAD (1000 B/H)	SEASONAL PLANT EFF. (PCT)	EQUIV. FULL-LOAD HOURS	ESTIMATED YEARLY LOAD (1000 BTU)
1 - ADMINISTRATION : GENERAL PURPOSE	HEAT	CHP	800.3	100.0	2165.5	1,733,020.
2 - DISPENSARY	HEAT	CHP	250.0	100.0	2165.5	541,582.
3 - TELEPHONE EXCHANGE	HEAT	CHP	243.9	100.0	2165.5	528,156.
4 - COMBAT VEHICLE PLANT	HEAT	CHP	63916.9	100.0	2165.5	138,409,616.
5 - HEATING PLANT	HEAT	CHP	3216.0	100.0	2165.5	6,964,143.
7 - VEHICLE AND MACHINE REPAIR	HEAT	CHP	3926.4	100.0	2626.5	10,312,719.
8 - EXPERIMENTAL LAB	HEAT	CHP	991.0	100.0	2626.5	2,602,869.
9 - FACILITIES ENGINEER MAINTENANCE SHOP	HEAT	CHP	1063.1	100.0	2165.5	2,302,104.
10 - FACILITIES ENGINEER MAINTENANCE SHOP	HEAT	CHP	154.8	100.0	2626.5	406,583.
12 - APPLIED INSTRUCTION	HEAT	CHP	1353.1	100.0	2165.5	2,930,087.
13 - OPEN MESS (OFFICERS CLUB)	HEAT	CHP	192.1	100.0	2165.5	415,985.
14 - OPEN MESS (NCO)	HEAT	CHP	144.5	100.0	1962.1	283,520.
15 - BACHELOR'S ENLISTED QUARTERS	HEAT	CHP	125.2	100.0	2165.5	323,954.
17 - FAMILY HOUSING	HEAT	CHP	149.6	100.0	2165.5	325,469.
18 - POST EXCHANGE AND COE OFFICE	HEAT	CHP	150.3	100.0	2165.5	325,469.
40 - TRACK/SUSPENSION LAB	HEAT	CHP	157.0	100.0	1350.4	212,008.
54 - FACILITIES ENGINEER MAINTENANCE SHOP	HEAT	CHP	125.5	100.0	2165.5	271,766.
55 - FACILITIES ENGINEER MAINTENANCE SHOP	HEAT	CHP	152.5	100.0	2165.5	330,233.
56 - FACILITIES ENGINEER MAINTENANCE SHOP	HEAT	CHP	196.3	100.0	2165.5	425,080.
57 - WASH RACK AND STORAGE	HEAT	CHP	584.5	100.0	1350.4	739,292.
58 - GENERAL STOREHOUSE	HEAT	CHP	1185.9	100.0	1886.2	2,236,795.
59 - LIFT TRUCK REPAIR	HEAT	CHP	1216.9	100.0	1886.2	2,295,266.
61 - FACILITIES ENGINEER MAINTENANCE SHOP	HEAT	CHP	607.6	100.0	1350.4	820,485.
200A - ADMINISTRATION : R&D ACTIVITIES	HEAT	CHP	1787.9	100.0	1886.2	3,372,262.
200B - ADMINISTRATION : GENERAL PURPOSE	HEAT	CHP	1920.6	100.0	1886.2	3,622,556.
200C - LAB & TEST : GENERAL PURPOSE	HEAT	CHP	2720.9	100.0	1886.2	5,132,048.
200D - EXPERIMENTAL SHOPS	HEAT	CHP	12143.9	100.0	2626.5	31,896,032.
201 - PRINTING PLANT	HEAT	CHP	754.3	100.0	2626.5	1,981,174.
202 - ROADS AND GROUNDS	HEAT	CHP	116.2	100.0	2165.5	251,627.
203 - GENERAL PURPOSE WAREHOUSE	HEAT	CHP	4042.5	100.0	2626.5	10,617,656.
205 - ENGINEERING ADMINISTRATION	HEAT	CHP	394.5	100.0	2165.5	854,275.
212 - PROPULSION SYSTEMS LABORATORY	HEAT	CHP	5393.1	100.0	2165.5	11,678,565.
215 - TRACK & SUSPENSION LAB	HEAT	CHP	1907.2	100.0	2165.5	4,129,971.
219 - MODEL SHOP	HEAT	CHP	2553.1	100.0	2626.5	6,705,736.
224 - FACILITIES ENGINEER MAINTENANCE SHOP	HEAT	CHP	168.8	100.0	2165.5	365,530.
225 - GENERAL STOREHOUSE	HEAT	CHP	0.1	100.0	711.4	71.
227 - SALVAGE & SURPLUS STORAGE	HEAT	CHP	426.1	100.0	2165.5	922,704.
230 - ADMINISTRATION : GENERAL PURPOSE	HEAT	CHP	7227.2	100.0	1886.2	13,631,644.
238 - BATH HOUSE	HEAT	GAS	66.9	60.0	1350.4	150,566.
TOTAL ESTIMATED HEATING ENERGY						271,042,006.

TABLE 12
SUMMARY OF ESTIMATED ANNUAL BUILDING HEATING ENERGY CONSUMPTION
ARSENAL ACRES, WARREN, MICHIGAN

BUILDING NUMBER AND TITLE	LOAD TYPE	ENERGY SOURCE	DESIGN LOAD (1000 B/H)	SEASONAL PLANT EFF. (PCT)	EQUIV. FULL-LOAD HOURS	ESTIMATED YEARLY LOAD (1000 BTU)
301 - COMMANDING OFFICER'S QUARTERS	HEAT	GAS	144.6	75.0	2165.5	417502.
302, 303 - SENIOR OFFICER'S QUARTERS	HEAT	GAS	135.6	75.0	2165.5	391517.
304-307 - JUNIOR OFFICERS' QUARTERS	HEAT	GAS	110.6	75.0	2165.5	319334.
TOTAL ESTIMATED HEATING ENERGY						2143083.

TABLE 13
SUMMARY OF ESTIMATED ANNUAL BUILDING HEATING ENERGY CONSUMPTION
PONTIAC STORAGE FACILITY, PONTIAC, MICHIGAN

BUILDING NUMBER AND TITLE	LOAD TYPE	ENERGY SOURCE	DESIGN LOAD (1000 B/H)	SEASONAL PLANT EFF. (PCT)	EQUIV. FULL-LOAD HOURS	ESTIMATED YEARLY LOAD (1000 BTU)
1 - GENERAL WAREHOUSE	HEAT	GAS	500.0	60.0	2165.5	1,804,551.
7 - HEATING PLANT	HEAT	GAS	2436.6	60.0	1350.4	5,483,855.
TOTAL ESTIMATED HEATING ENERGY						7,288,406.

TABLE 14
SUMMARY OF ESTIMATED ANNUAL BUILDING HEATING ENERGY CONSUMPTION
KEWEENAW FIELD STATION, HOUGHTON, MICHIGAN

BUILDING NUMBER AND TITLE	LOAD TYPE	ENERGY SOURCE	DESIGN LOAD (1000 B/H)	SEASONAL PLANT EFF. (PCT)	EQUIV. FULL-LOAD HOURS	ESTIMATED YEARLY LOAD (1000 BTU)
1 - ADMINISTRATION : GENERAL PURPOSE	HEAT	GAS	253.7	75.0	2553.3	863,683.
2 - VEHICLE GARAGE - MACHINE SHOP	HEAT	GAS	160.9	75.0	2553.3	547,759.
3 - VEHICLE STORAGE	HEAT	GAS	218.3	80.0	303.0	82,681.
5 - GENERAL LABORATORY	HEAT	GAS	225.4	75.0	2112.0	634,719.
TOTAL ESTIMATED HEATING ENERGY						2,128,842.

TABLE 15
DESCRIPTION OF EEAP GENERATED PROJECTS

Project	Description
A-1/Reduce Window Area for Buildings 7, 212 and 219	Removal of existing window systems and installation of translucent insulating panels in Buildings 7, 212 and 219.
A-2/ECOs for Buildings at DA and Satellites	Those ECOs identified under Increment A: <ul style="list-style-type: none"> ● Insulate Walls ● Upgrade Window Systems ● Install High Efficiency Lamps ● Convert to VAV
B-1/Modifications to Electrical and Steam Distribution Systems	Those ECOs identified under Increment B: <ul style="list-style-type: none"> ● Convert Street Lighting to HPS ● Insulate PRV Stations ● Insulate Aboveground Steam Lines ● Institute a Steam Trap Inspection and Replacement Program ● Replace Fire-Protection Water Heater at PSF
B-2/Energy Monitoring and Control System (EMCS)	Installation of an EMCS with ability for: <ul style="list-style-type: none"> ● Lighting Level Control ● Timeclock AHUs ● Timeclock EFs ● Reduce Ventilation Air ● Optimize Temperature Control ● Reset Hot Water Temperature ● Unoccupied Heating Shutdown ● Night Setback
D-1/Cogeneration System	Installation of a cogeneration system in Building 5 for production of electricity and steam.
F-1/Low Cost ECOs	Low cost ECOs identified for buildings throughout the site: <ul style="list-style-type: none"> ● Reduce Infiltration ● Install Door Seals ● Delamp ● Install DHW Controls ● Install Spark Ignition
F-2/ECOs for GOCO Buildings 4, 5, and 59	Install lighting level controls in Building 4, reclaim heat generated by air compressors in Building 5, and reduce the ventilation air for Building 59.

TABLE 15 (Cont'd.)
DESCRIPTION OF EEAP GENERATED PROJECTS

Project	Description
F-3/ECOs for Housing at Arsenal Acres	Those low cost ECOs identified under Increment A for Arsenal Acres housing units: <ul style="list-style-type: none"> • Upgrade Window Systems • Weatherstrip and Caulk • Night Setback • Spark Ignition • Flue Dampers
F-4/Special Application ECOs	Those low cost ECOs identified under Increment A as a result of the observation of special operational procedures or environmental conditions during field surveys (e.g., install economizers for ADP AHUs in Building 230).
F-5/Building 4 Surface Treatment Tanks	Insulation of surface treatment tanks and installation of tank covers.
F-6/Building 229 and 231 Elevator Heat Recovery	Recovery of waste heat from elevator hydraulic systems to preheat domestic hot water.
G-1/Non-Qualifying Building ECOs	Those ECOs identified under Increment A which do not meet ECIP criteria for E/C or B/C ratios.
G-2A/Electrical Submetering of Selected Buildings	Installation of electric consumption meters in Buildings 1, 4, 5, 7, 12, 58, 59, 200A, 200B, 200C, 200D, 203, 205, 212, 215, 219 and 230.
G-2B/Steam Submetering of Selected Buildings	Installation of condensate meters in order to monitor steam usage in Buildings 1/2/3, 12-22/37, 7/8/11/40, 4/6/23, 9/10/57/61, 54/55/56/72, 58/59/63, 200A/200B/200C/200D, 201/202/224/227, 203/205, 212, 215, 219/233 and 230.
G-2C/Shutoff Little used Compressed Air Lines	Installing shutoff valves into existing compressed air lines.
G-3/EMCS for Keweenaw Field Station	Energy Monitoring and Control System for Buildings 1 and 5.
G-4/EMCS for Pontiac Storage Facility	Energy Monitoring and Control System for Building 1.

TABLE 16

ENERGY ENGINEERING ANALYSIS PROGRAM
DETROIT ARSENAL AND SATELLITES

SUMMARY OF PROJECTS

PROJECT TITLE	ANNUAL ENERGY SAVINGS				TOTAL (MBTU)	DOLLAR SAVINGS (\$ 1000)		COST (\$1000/S FY86)		ECIP RATIOS		
	ELECT. (KWH)	NAT. GAS (KCF)	COAL (TONS)	FUEL OIL (GAL)		ANNUAL (FY86)	TOTAL BENEFIT	CWE	TIC	E/C	B/C	PAY BACK
ECIP QUALIFYING PROJECTS:												
F-2 / ECOS FOR GOCO BLDGS 4, 5, 59	39417.	0.	549.	0.	13955.	50.7	605.0	15.7	17.6	833.7	34.5	0.3
F-5 / BLDG 4 SURFACE TREATMENT TANKS	0.	0.	527.	0.	12950.	43.9	218.8	18.7	19.7	690.8	11.1	0.4
F-1 / LOW COST ECOS FOR DA & SATELLITES	57755.	1174.	149.	0.	6020.	34.7	423.1	9.3	9.8	645.4	43.2	0.3
F-4 / SPECIAL APPLICATION ECOS FOR BLDGS AT-DA	236948.	0.	115.	0.	5571.	30.0	356.5	29.0	30.4	192.2	11.7	1.0
D-1 / COGENERATION SYSTEM	4278112.	0.	-862.	0.	28420.	329.2	6452.4	664.8	697.4	42.7	9.3	2.0
F-3 / ECOS FOR HOUSING AT ARSENAL ACRES	4609.	1237.	0.	0.	1330.	9.0	189.8	35.1	36.8	37.9	5.2	3.9
B-2 / EMCS FOR DA	1203586.	0.	2654.	0.	79200.	242.6	3102.0	2209.9	2318.3	35.8	1.3	9.1
A-2 / RETROFIT MOD. FOR BLDGS AT DA & SATELLITES	172338.	45.	319.	0.	9878.	45.7	705.0	284.1	298.0	34.8	2.4	6.2
B-1 / MODIFICATIONS TO ELECT. AND STEAM DIST. SYSTEMS	131200.	0.	592.	40090.	21616.	158.6	2070.6	685.2	689.0	31.6	3.0	4.1
A-1 / REDUCE WINDOW AREA FOR BLDGS 7, 212, & 219	52586.	0.	594.	0.	15206.	61.5	923.6	593.6	622.7	25.6	1.5	9.6

TABLE 16 (Cont'd)

ENERGY ENGINEERING ANALYSIS PROGRAM
DETROIT ARSENAL AND SATELLITES

SUMMARY OF PROJECTS

PROJECT TITLE	ANNUAL ENERGY SAVINGS				DOLLAR SAVINGS		COST (\$1000'S FY86)		ECIP RATIOS		
	ELECT. (KWH)	NAT GAS (KCF)	COAL (TONS)	FUEL OIL (GAL)	TOTAL (MBTU)	ANNUAL (FY86)	TOTAL BENEFIT	CWE TIC	E/C	B/C	PAY BACK
<u>NON-ECIP QUALIFYING PROJECTS:</u>											
F-5 / ELEVATOR HEAT RECOVERY BLDGS 229 & 231	12875.	0.	0.	0.	149.	0.3	8.3	9.9	15.1	0.8	33.8
G-4 / EMCS AT PSF	513.	0.	0.	3426.	481.	6.5	96.2	40.9	11.8	2.2	6.3
G-3 / EMCS AT KFS	399.	339.	0.	0.	354.	0.4	14.7	37.6	9.4	0.4	107.1
G-1 / NON-QUALIFYING BUILDING ECOS	-96343.	271.	524.	0.	12038.	10.9	308.9	1708.2	7.0	0.2	156.8
G-2C / CLOSE OFF INFREQ. USED COMPRESSED AIR LINES	1377.	0.	0.	0.	16.	0.1	1.5	13.2	1.2	0.1	109.6
G-2A / ELECTRICAL SUBMETERING	0.	0.	0.	0.	0.	0.0	0.0	30.0	0.0	0.0	NONE
G-2B / CONDENSATE SUBMETERING	0.	0.	0.	0.	0.	0.0	0.0	35.5	0.0	0.0	NONE

projects. Figure 5 describes the degree to which interactions between projects will affect the energy savings credited to those projects. The projects listed as 'independent' are assumed to be implemented first. The effect on each of the other 'dependent' projects is then categorized as 'none', 'minimal' or 'significant'. All of the projects which presently qualify for ECIP funding would still meet ECIP criteria even if interactive effects on energy savings were taken into account.

Energy Goals and Projected Site Energy Usage

According to the most recent DEIS reports, FY75 energy consumption at Detroit Arsenal (DA) totaled 1,305,255 MBTU. The Army Facilities Energy Plan (AFEP) established a goal of 25% reduction in energy consumption from FY75 to FY85. In order to meet this goal, the level of energy consumption at DA must be reduced to 978,941 MBTU/YR by October 1984.

Figure 6 depicts the DA energy consumption for the period FY75 through FY83 based upon the DEIS reports along with the AFEP FY85 goal. As can be seen, energy consumption at DA peaked in FY81 and since has decreased to a level of 1,234,911 MBTU (est.) in FY83, some 5.4% below the FY75 value.

Implementation of the 10 projects summarized in Table 16 which meet ECIP criteria would achieve a reduction in energy consumption of 194,000 MBTU/YR. This would bring the DA consumption level to 1,040,911 MBTU/YR, still above the target of 978,941 MBTU/YR. The projects developed for this EEAP do not recommend many ECOs for Building 4, the major user of energy. This was the direction agreed upon at prenegotiation meetings. The DA Facilities Engineering staff had already focused attention on Building 4 and identified several projects which are now being implemented. These projects include replacing the large window sections that made up most of the exterior

Dependent Project

Independent Project	F-2 / ECOS FOR GOCO BLDGS 4, 5, 59	F-5 / BLDG 4 SURFACE TREATMENT TANKS	F-1 / LOW COST ECOS FOR DA & SATELLITES	F-4 / SPECIAL APPLICATION ECOS FOR BLDGS AT DA	D-1 / COGENERATION SYSTEM	F-3 / ECOS FOR HOUSING AT ARSENAL ACRES	B-2 / EMCS FOR DA	A-2 / RETROFIT MOD. FOR BLDGS AT DA & SATELLITES	B-1 / MODIFICATIONS TO ELECT. AND STEAM DIST. SYSTEMS	A-1 / REDUCE WINDOW AREA FOR BLDGS 7, 212, & 219
F-2 / ECOS FOR GOCO BLDGS 4, 5, 59										
F-5 / BLDG 4 SURFACE TREATMENT TANKS										
F-1 / LOW COST ECOS FOR DA & SATELLITES										
F-4 / SPECIAL APPLICATION ECOS FOR BLDGS AT DA										
D-1 / COGENERATION SYSTEM										
F-3 / ECOS FOR HOUSING AT ARSENAL ACRES										
B-2 / EMCS FOR DA										
A-2 / RETROFIT MOD. FOR BLDGS AT DA & SATELLITES										
B-1 / MODIFICATIONS TO ELECT. AND STEAM DIST. SYSTEMS										
A-1 / REDUCE WINDOW AREA FOR BLDGS 7, 212, & 219										

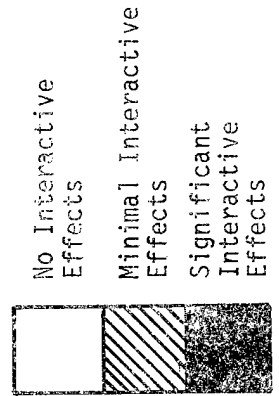


Figure 5 EFFECT OF INTERACTIONS BETWEEN PROJECTS ON ENERGY SAVINGS

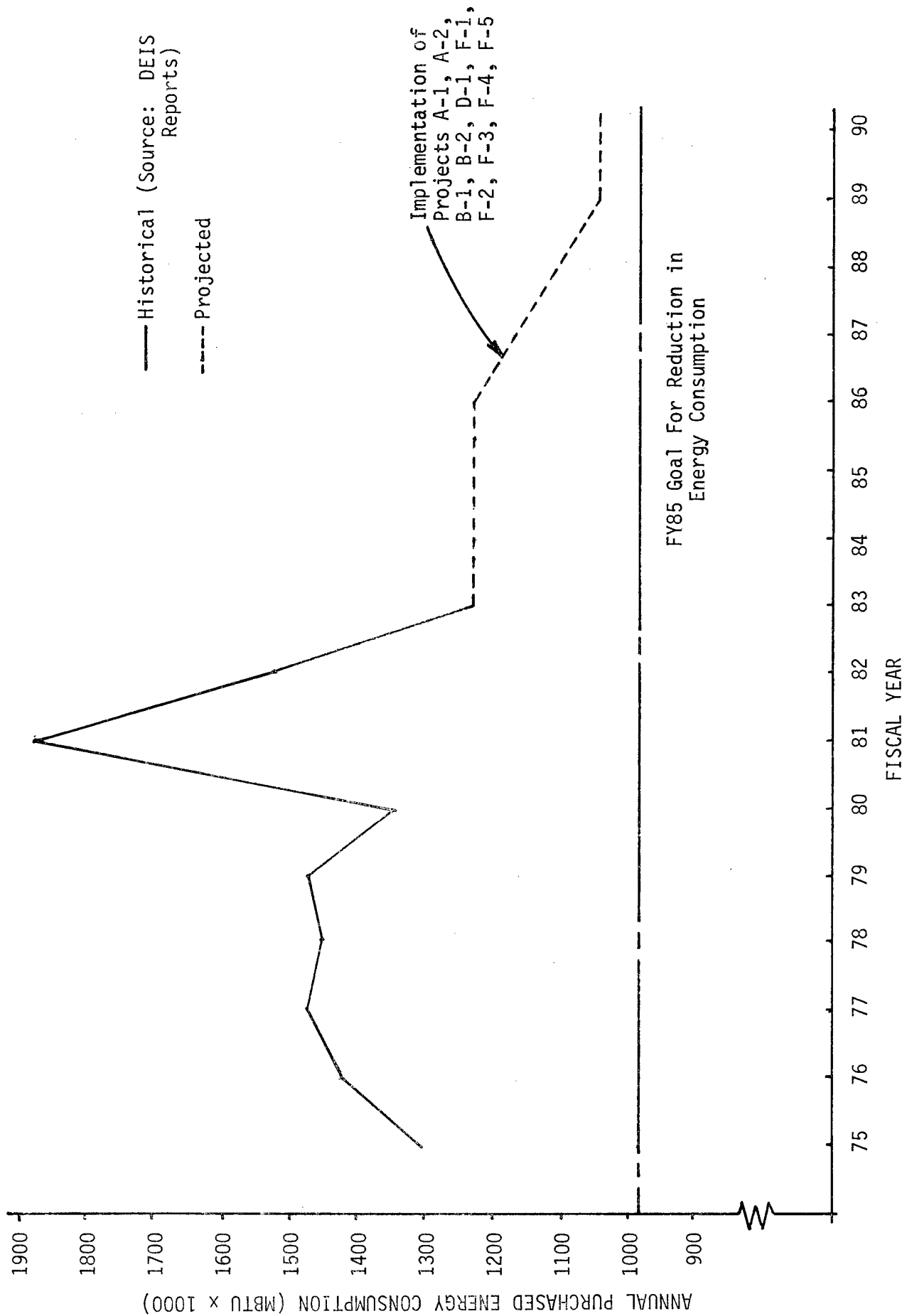


Figure 6 PROJECTED DETROIT ARSENAL ENERGY CONSUMPTION

skin with insulated panels, removing obsolete skylights, installing high efficiency lighting and installing an EMCS. Some of these projects have been recently completed and in fact have contributed to the drop in the energy consumption level in FY82 and FY83. Building 4 offers the best potential for achieving additional savings which would put the installation energy consumption below the FY85 goal.

ECIP funding for the projects generated under this study will not be available until FY86 and it will probably be three to four years after that time before all of the qualifying projects are funded and implemented. For this reason alone, DA may not be able to meet the AFEP goal by FY85. Even with complete and immediate funding, the goal is probably unattainable unless the energy consumption of production processes are addressed.